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Handwritten Signature Verification System using Sobel Operator and KNN Classifier

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ABSTRACT

Signature is one of the most widely accepted personal attributes for identity verification. Signature verification is a scheme to verify cheque for bank security. So, this system is proposed as the off-line handwritten signature verification system for the bank cheque image processing. In any offline signature verification system, feature extraction stage is the most vital and difficult stage. In this system, sobel gradient operator is used to extract signature features. After extracting features, this system performs the verification process by using k-nearest neighbor (KNN) classifier. This system supports the security about the bank processing by verifying user signature from the bank cheque.

KEYWORDS: *Signature, Verification, Sobel, KNN.*

1. INTRODUCTION

Today, signature verification is an important research area in the field of personal authentication. Signature verification is useful for banking and passport verification system. Signature verification system can be classified into two categories that are on-line and offline. In an offline technique, signature is signed on a piece of paper and scanned to computer system. In an online technique, signature is signed on a digitizer and dynamic information like speed, pressure is captured in addition to a static image of signature.

Automated verification of signatures became imperative when it was difficult to distinguish genuine signatures from simulated forgeries on the basis of visual assessment.

This led to the more reliable and efficient computer signature verification. Due to the importance of signature, this system is proposed as the automatic signature verification system for bank cheques.

To verify the signature from the bank cheque, this system uses both the feature extraction and the verification methods. There are many feature extraction and verification methods. Among them, the sobel edge detection operator is used to extract features from the bank cheque. In the verification process, this system uses the k-nearest neighbor (KNN) classifier among other classification methods. In the KNN classification method, the test signature is compared to all the signatures in the reference set according to the several dissimilarity/ distance values. So, this system is designed to process the handwritten signatures and verify for it correctness.

2. Related Work

In 2015, C. V. Khatode and S. S. Morade [1] proposed the methodology for extraction of signature features from a bank cheque. This system compared the extracted features with the stored features to analyze whether the signature is of the verified person or not. If the signature matches, the whole data of customer with whom the signature has matched is displayed onto the screen. After matching, the cheque can be sent for clearance. This system is developed to avoid the forgeries taking place in the banking environment.

In 2018, V. Tambade, P. Varma and A. Sonawale [2] presented the bank cheque signature verification system. In this system, an artificial neural network based on the Back-propagation algorithm is used for recognition and verification. This system was tested with 400 test signature samples, which include genuine and forged signatures of twenty individuals. This system allowed for judging signature accuracy, and achieving more effective results.

In 2019, T. Jadhav [3] presented the handwritten signature verification system by using local binary pattern features and k-nearest neighbor (KNN) classifier. They intended to give away information about the application of biometric i.e. signature detection. This system worked in different stages which includes pre-processing, local binary pattern (LBP) image conversion, feature extraction, and classification. This system compared the output with another existing system.

3. Feature Extraction

Feature extraction is to reduce the original data set by measuring certain properties of features that distinguish on input pattern from another [5]. Feature extraction is performed to collect similar unique properties of a signature. Various methods are available for creating features from the signature image. All these methods can be classified into direct and indirect methods. Direct methods use feature values from image pixels like grid based information, gray-level information and pixel density. Whereas in indirect methods, transformations like fourier, wavelet and radon are

applied. In this system, direct method is used. There are three types of features. They are shape, grid and texture features [4].

3.1. Sobel Gradient Operator

Edge detection techniques remove noise and ineffective data still preserving the important structural properties of the image [7]. Sobel gradient operator is used for feature extraction. The sobel operator is based on convolving the image with a small, separable, and integer valued filter [6]. It works by calculating the gradient of image intensity at each pixel within an image.

Sobel filter uses two 3 x 3 kernels. One changes in the horizontal direction, and one changes in the vertical direction. The two kernels are convolved with the original image to calculate the approximations of the derivatives. G_x and G_y are defined as two images that contain the horizontal and vertical derivative approximations respectively. The computations are as follows:

$$G_X = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} * A \quad (1)$$

$$G_y = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A \quad (2)$$

where A is original source image. The x coordinate is defined as increasing in horizontal-direction and the y coordinate is defined as increasing in vertical-direction. At each pixel in image, the gradient approximations given by G_x and G_y are combined to give the gradient magnitude that is as follows:

$$|G| = \sqrt{G_x^2 + G_y^2} \quad (3)$$

This sobel gradient operator finds the direction of the largest increase from light to dark and the rate of change in that direction. The result shows how smoothly the image changes at each pixel, and therefore how likely it is that pixel represents an edge. It also shows how that edge is likely to be oriented [6].

4. Signature Verification

After feature extraction, a signature image is represented as a feature vector of complex valued coefficients. Two signatures are determined whether from the same class by comparing the similarity between the corresponding feature vectors. It is a trivial task for image matching. K-nearest neighbor (KNN) classifier is useful for signature verification.

4. 1. K-Nearest Neighbor (KNN)

K-nearest neighbor (KNN) classifiers are based on learning by analogy. Training features are described by "n" dimensional numeric attributes. All training images are stored in an n-dimensional pattern space. When given an unknown image, a k-nearest neighbor classifier searches the pattern space for the k training images that are closest to the unknown sample. "Closeness" is defined in terms of Euclidean distance, where the Euclidean distance, where the Euclidean distance between two points, $X=(x_1, x_2,\ldots\ldots, x_n)$ and $Y=(y_1, y_2,\ldots, y_n)$ is

$$d(X,Y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2} \quad (4)$$

KNN classifier algorithm is as follows:

- Step 1: determine k
- Step 2: calculate the distance between the new input image and all the training images
- Step 3: sort distance and determine k nearest neighbors based on k^{th} minimum distance
- Step 4: gather the categories of those neighbors
- Step 5: determine the categories based on majority vote [9].

5. Proposed System Design

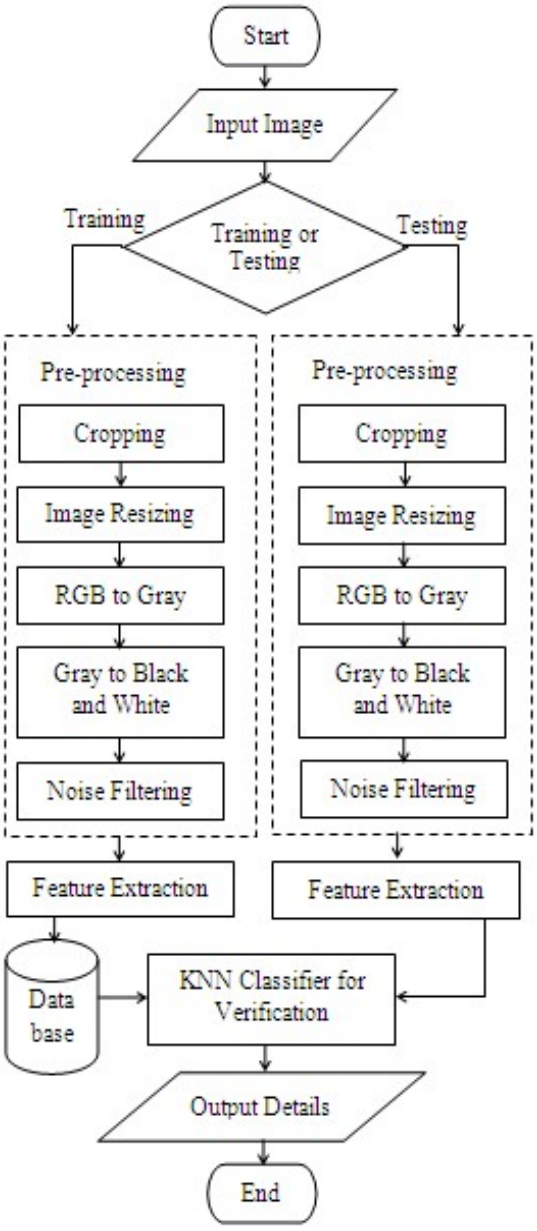

Figure1. Proposed System Design

Proposed system design is shown in Figure1. This system is proposed as the handwritten signature verification system. In this system, the user must first input bank cheque for training or testing data. After receiving the bank cheque image, this system performs the pre-processing that includes cropping, resizing, color to gray, gray to black and white, and noise elimination sub-processes.

Then, this system uses the sobel gradient operator for feature extraction and the k-nearest neighbor (KNN) classifier for feature verification. Finally, this system produces the correct or incorrect information.

5.1. Image Acquisition

Bank cheque images can be acquired through the scanner or camera. Bank cheque is shown in Figure2.

Figure2. Input Bank Cheque

5.2. Cropping

Cropping method is to locate a rectangular box around an object of interest and remove other objects outside this area. Cropping method works by moving four vectors from four different directions. Cropping image is shown in Figure3.

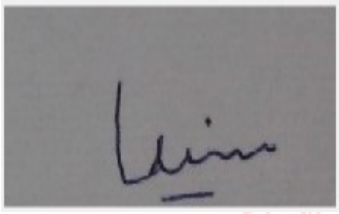

Figure3. Cropping Image

Manual cropping is achieved using Matlab function (imcrop). Auto cropping is saving more work and the cropping rectangle is truly detecting.

5.3. Resizing

Resizing is an intrinsic change in the size of the image. Resizing is needed to increase or decrease the total number of pixels. Changing an image size from 1000 pixels to 500 pixels is resizing. Resizing affects not only the real size of the image but also potentially its weight. Resizing image is shown in Figure4.

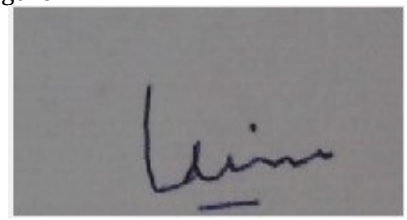

Figure4. Resizing Image

5.4. Color to Grayscale Image

The difference color may be difficult to train a system based on recognition. The grayscale image is 0 (black) to 255 (white) each pixels. Grayscale image is shown in Figure5.

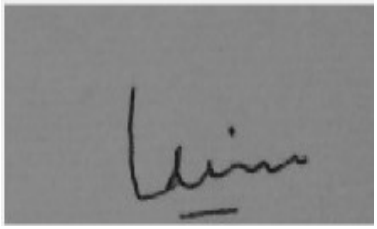

Figure5. Grayscale Image

5.5. Grayscale to Black and White Image

All grayscale images were converted to black and white images which is represent by 1 and black by 0. The signature part of the image was represented by 0 and black parts of the image by 1. Black and white image is shown in Figure6.

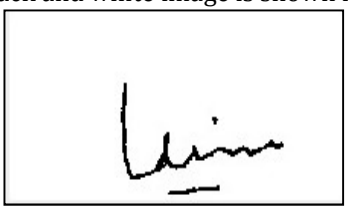

Figure6. Black and White Image

5.6. Noise Reduction

The noise may come from the camera or the optical device captures the image. Most scanned image contains noise in form of darker dots and disturbances caused by the scanning process. Median filters method can remove from an image without significantly reducing the sharpness of the image. Median filters can do an excellent job of rejecting certain types of noise. Noise filtered image is shown in Figure7.

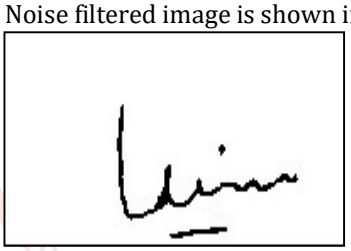

Figure7. Noise Filtered Image

5.7. Sobel Image from Feature Extraction

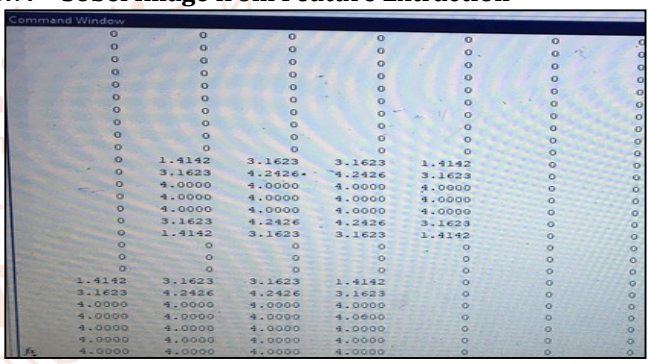

Figure8. Results from Sobel Operator

After finishing pre-processing step, this system extracts features from the noise filtered image. This system uses sobel gradient operator to extract features. This operator produces each gradient value as the features. Sample gradient values are shown in Figure8. Sobel image is shown in Figure9.

Figure9. Sobel Image

5.8. KNN Classification for Verification

By using signature testing and each training signature features, this system classifies the testing signature that is correct or incorrect. If the distance between testing and training signature is "0", the system produces the inputted (testing) signature is correct.

6. Experimental Result of the System

To measure the performance of verification process, this system uses the false rejection rate (FRR) and false acceptance rate (FAR). This system is tested by using 70 images from different person. The FAR and FRR results for signature verification system are shown in Table 1.

Table1. FAR and FRR Results of the System

ID	Types of Person	No of Signatures	False Accepted Rate (FAR)	False Rejection Rate (FRR)
1	Person 1	10	2	1
2	Person 2	10	1	2
3	Person 3	10	1	1
4	Person 4	10	2	1
5	Person 5	10	1	1
6	Person 6	10	1	2
7	Person 7	10	1	2

.

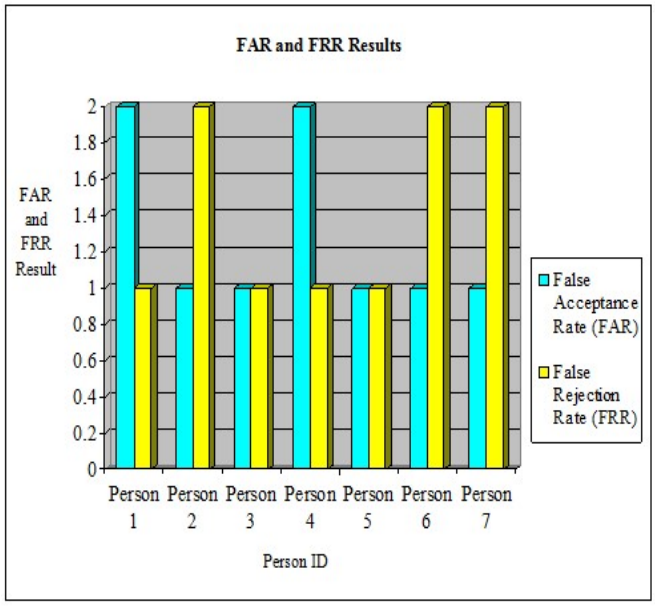

Figure10. Experimental Result of the System

7. Conclusion

This system presented the off line bank cheque handwritten signature verification system by using edge detection method and classification method. Signatures are accepted as a means of a person's identification in all legal and commercial transaction. So, verification is very important in security and resource access control. Finally, the proposed system is effective by providing both security approach for the bank cheque and, magnitude results based feature extraction technique for bank cheque verification.

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